Parity Nonconservation in Stable Yb Isotopes

C.J. Bowers, D. Budker †‡, B. DeBoo†, D. DeMille §, S.J. Freedman †‡, D.F. Kimball†, J.E. Stalnaker †‡, and V. Yashchuk†*

The weak interaction, best known for its role in nuclear beta decay, also plays a minor role in the electronic structure of atoms. Although atomic structure is dominated by the electromagnetic interaction, it is possible to study the weak interaction in atoms by observing parity-nonconserving (PNC) effects.

The $6s^2\ {}^1S_0 \rightarrow 5d6s\ {}^3D_1$ transition in atomic ytterbium (Yb) is a promising system for the study of atomic PNC [1]. In the absence of parity nonconservation, the transition is strictly forbidden as an E1, and occurs only through a highly suppressed M1 transition. The application of an external electric field mixes even and odd parity states, giving rise to a Stark-induced amplitude ($E1_{Stark}$). The weak interaction also mixes even and odd parity states, giving rise to a parity-nonconserving amplitude ($E1_{PNC}$). In order to measure the very small $E1_{PNC}$, the transition is excited by intense laser light in the presence of an electric field and the interference between $E1_{PNC}$ and the much larger $E1_{Stark}$ is observed. The parity-nonconserving effect in Yb is expected to be very large, due to the presence of two energetically-nearby states of opposite parity.

Comparing PNC effects in several stable isotopes of Yb may allow us to extract information about the weak interaction independent of the knowledge of atomic structure. The PNC effect for a given isotope also depends on the distribution of neutrons within the nucleus, a nuclear property not readily accessible by other means. In addition, comparison of PNC effects in the different hyperfine components of the two odd isotopes of Yb will allow for a determination of the nuclear anapole moment.

In the past year we have completed an absolute measurement of the Stark-induced transition amplitude, hyperfine structure, isotope shifts, and Stark-shifts for the $6s^2\ {}^1S_0 \rightarrow 5d6s\ {}^3D_1$ transition at 408 nm [2]. In addition, we are looking into the possibility of performing a PNC experiment in a vapor cell. We have finished a measurement of the collisional de-excitation cross section of the $6s6p\ {}^3P_0$ metastable state with helium and neon buffer gases and our results suggest that a PNC vapor cell experiment is possible [3]. We are currently working on a measurement of the highly suppressed M1 transition amplitude for the $6s^2\ {}^1S_0 \rightarrow 5d6s\ {}^3D_1$ transition through the method of Stark interference and are developing an experiment to measure the ac Stark-shifts for the transition.

Footnotes and References

*Present Address: SBC Technology Resources Inc. 9505 Aboretorum Blvd., Austin, TX 78759

† Department of Physics, University of California at Berkeley, Berkeley, CA 94720-7300

‡ Nuclear Science Division, Lawrence Berkeley National Laboratory, Berkeley, CA 94720

§ Department of Physics, Yale University, New Haven, Connecticut 06520

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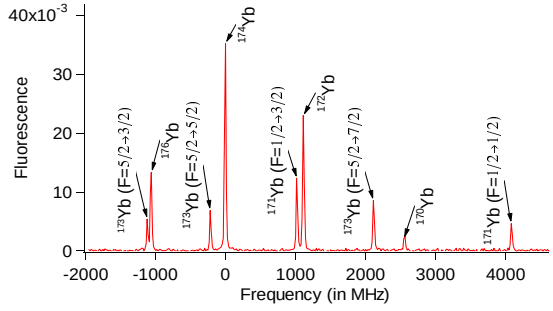

Fig.1 Laser-excitation spectrum of the 408 nm transition observed via fluorescence at 556 nm for the different isotopes and hyperfine components observed with a highly collimated atomic beam.